VMAP

Vegetation Management Alternatives Program

ANNUAL REPORT 1991-92

Ministry of Natural Resources
Ontario

Ontario Forest Research Institute
OFRI • IRFO

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Vegetation Management Alternatives Program

ANNUAL REPORT 1991-1992

JULY 1992

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Ministry of Natural Resources
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Cover Photo: **Brushsaw with Enso herbicide applicator being used.**
(Photo by Len Godwin)

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HIGHLIGHTS FOR 1991/92

Organizational

- VMAP Prospectus completed
- delivery structure for the VMAP in place
- six new staff in OFRI dedicated to the VMAP research and education program
- six new staff in regions dedicated to the VMAP field delivery program
- four forest companies formally joined the program

Adaptive Research

- sheep grazing successful for forest vegetation control in a pilot study
- manual and chemical release treatments being compared at several locations
- ground application methods for conifer release improved tree growth
- mechanical mulching machine improved site access
- mulches and tree shelters show potential for regenerating southern Ontario hardwoods
- cover cropping tested as a vegetation management alternative
- manual and chemical site-preparation methods compared in Central region
- techniques to reduce aerial spray drift developed
- better methods to assess competing vegetation developed
- data base on vegetation management treatment effects initiated
- Vision®herbicide successfully controlled raspberry and blue-joint grass at lower rates

Fundamental Research

- fungal pathogen (Bipolaris) shows potential for biological control of blue-joint grass
- natural phytotoxin (Bialaphos) for control of red raspberry and Kalmia being refined
- natural phytotoxin screening facility established in Sault Ste. Marie
- environmental impacts of prescribed fire being assessed

Technology Transfer

- first annual Advanced Forest Herbicides Course organized
- literature review of forest seedbanks completed
- province-wide literature review on forest plant autecology near completion
- northwestern Ontario vegetation management strategies course notebook revised
- central and southern Ontario prescribed fire review underway
- review of alternative vegetation management techniques in northern and southern Ontario initiated
- public education on the VMAP initiated through newspaper, radio, and television spots
- 50 publications produced
- 21 presentations made by VMAP staff

Organizational Responsibilities for the VMAP:

The VMAP is a component of The Ontario Ministry of Natural Resources (OMNR) Sustainable Forestry Program, announced in May 1991. Those responsible for achieving its goals are:

C.J. (Bud) Wildman, Minister of Natural Resources

Policy Division

David Balsillie Assistant Deputy Minister	**Robert Elliot** Director	**Geoff Munro** Manager Policy Development	**Mike Millar** General Manager Ontario Forest Research Institute

Operations Division

Science and Technology Units

Guy Winterton Manager, Northwest	**Al Willcocks** Manager, Northeast	**Harry Orr** Manager, Central	**Ken Vogan** Manager, Southern

VMAP Staff at the Ontario Forest Research Institute

Robert Wagner
Program Leader

Wayne Bell Research Scientist Treatment Alternatives	**R.A. Lautenschlager** Research Scientist Forest Ecosystems	**Michael Ter-Mikaelian** Research Scientist Modelling Responses

Lisa Buse Education and Communications	**Joanie Rudzki** Secretary

VMAP Staff at the Science and Technology Units

Chris Hollstedt Forester Northwest Region	**Susan Pickering** Forester Northeast Region	**Andrée Morneault** Program Leader Central Region	**Silvia Strobl** Plantation Specialist Southern Region
	Bruce Richard Technician Northeast Region	**Dianne Othmer** Technician Central Region	

Forest Industry Cooperators

Boise Cascade Canada, Ltd., Fort Frances	**Canadian Pacific Forest Products, Ltd.,** Thunder Bay	**E.B. Eddy Forest Products, Ltd.** Espanola	**Quebec and Ontario Paper Co. Ltd.,** Hornepayne

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INTRODUCTION

Successful regeneration of harvested forest lands requires that young forests be protected from non-crop vegetation (including some hardwoods, shrubs, grasses, and forbs). These fast-growing plants often kill or greatly suppress desired trees by robbing them of the light, water, and nutrients needed to grow.

For the past several decades, aerially-applied herbicides have been the primary method developed and used to suppress non-crop vegetation in Ontario's forests. Greater environmental awareness has increased public concern over herbicide use in the forest. This concern has prompted forest managers to seek alternative approaches to managing non-crop vegetation. Unfortunately, adequate alternatives do not currently exist for most of Ontario's forest conditions.

The goal of the Vegetation Management Alternatives Program (VMAP) is to develop approaches to managing forest vegetation that will gradually reduce dependence on herbicides in Ontario's forests. This goal is being accomplished by developing alternatives to current uses of forest herbicides, and by gaining a better understanding of forest ecosystems. The principal components of the program include adaptive research, fundamental research, education, and field delivery. A primary objective of the VMAP is to provide leadership in advancing all aspects of forest vegetation management in Ontario.

This report completes the first year of the VMAP. First-year productivity for the program was excellent. Our success has been due to the excellent support received from the Ontario Ministry of Natural Resources (OMNR) Sustainable Forestry Program, OMNR regional Science and Technology Units (formerly Technology Development Units), OMNR district field staff, and forest industry. Researchers from Forestry Canada and universities are also significant contributors to the VMAP efforts. The following annual report describes the organizational accomplishments, research study results, and technology transfer and educational activities of the VMAP during fiscal year 1991-92.

ORGANIZATIONAL ACCOMPLISHMENTS

Much of the first year involved establishing the design and delivery mechanism for the program. This task was accomplished by a Forest Vegetation Management Task Force, the regional Technology Development Units, and OMNR executives. We appreciate the contributions of those who participated in these efforts.

Prospectus

Completion of the VMAP Prospectus established the foundation for the program (Figure 1). This document describes the history leading to the program's establishment, goal of the program, program design, delivery mechanism, and program length and review.

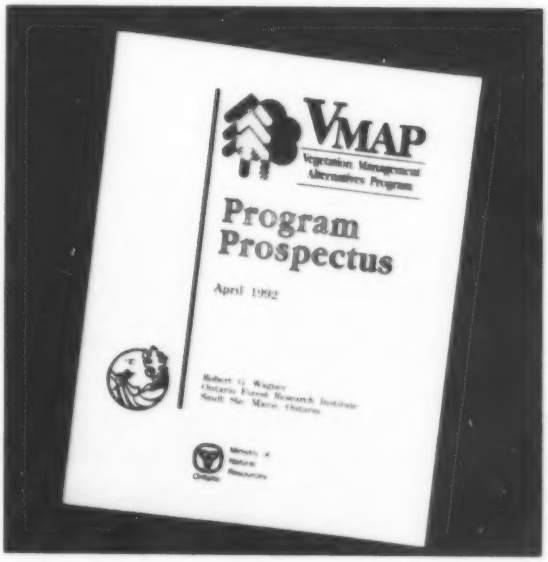

Figure 1. The VMAP Prospectus.

Delivery Structure

Developing the organizational structure to deliver the program was one of this year's most significant accomplishments. Re-organization of the OMNR presented a few challenges, but solutions were found to transfer delivery of the VMAP from the old organization to the new one.

The principal organizational components of the program include forest management organizations, the VMAP Technical Committee, the Sustainable Forestry Steering Committee, the four new regional Science and Technology Units, the Ontario Forest Research Institute (OFRI), the Agricultural Research Institute of Ontario (ARIO) Research Committee, and research institutions across the province. The specific roles and responsibilities for each of these organizational components are described in the VMAP Prospectus. The general relationship among these components is shown in Figure 2.

New Staff

Hiring new staff to deliver the program was an important first year activity. These positions are required to coordinate various aspects of the program. Current staff at the OFRI and regional Science and Technology Units dedicated to the VMAP include:

Dr. Bob Wagner, VMAP Leader - Bob was previously the Provincial Vegetation Management Specialist for the OMNR Forest Health and Protection Section in Sault Ste. Marie. He has a B. S. in forest management from Utah State University, an M. S. in forest ecology from the University of Washington, and a Ph. D. in silviculture from Oregon State University. Prior to coming to Ontario, Bob helped build a successful vegetation management research cooperative at Oregon State University. Bob is responsible for provincial coordination and leadership of the VMAP.

Forest Management Organizations
VMAP Technical Committee
Sustainable Forestry Steering Committee
Northwest Region Science & Technology Unit
Northeast Region Science & Technology Unit
Ontario Forest Research Institute
Central Region Science & Technology Unit
Southern Region Science & Technology Unit
ARIO Research Committee
Research Institutions

Figure 2. VMAP organizational structure.

F. Wayne Bell, Vegetation Management Scientist - Wayne has joined us from the former Northwestern Ontario Forest Technology Development Unit (NWOFTDU) where he was the special projects forester responsible for vegetation management, growth and yield, and workshop coordination. Wayne has a B. Sc. and an M. Sc. in forestry specializing in silviculture from Lakehead University. Wayne is responsible for the treatment alternatives portion of the VMAP as well as acting as liaison to the regional Science and Technology Units.

Dr. R.A. Lautenschlager, Vegetation Management Scientist - R.A. previously worked with the Cooperative Forestry Research Unit and the College of Forest Resources at the University of Maine; the USDA Forest Service, Northeastern Forest Experiment Station in Connecticut; and the Wildlife Unit of Connecticut's Department of Environmental Protection. He has a B. Sc. in wildlife management from the University of Connecticut, an M. F. S. in forest ecology from Yale University, and a Ph. D. in forest resources from the University of Maine. He has also taught forest and wildlife ecology at three universities in the United States. R.A. is responsible for the forest ecosystem responses component of the VMAP.

Dr. Michael Ter-Mikaelian, Forest Modeller - Soon to arrive from the Institute of Global Climate and Ecology in Moscow, Russia, where he was senior research scientist, Michael has an M. Sc. in mathematics from the Moscow Institute of Electronic Machine Building and a Ph. D. in environmental protection and natural resource management from the Institute of Global Climate and Ecology. Michael will be responsible for modelling vegetation management responses of young forest stands.

Lisa Buse, Education and Communications Coordinator - Lisa was previously acting black spruce program forester with the former NWOFTDU, where she was responsible for development projects, extension services, and workshops relating to black spruce. Lisa has a B. Sc. in agriculture (environmental biology) from the University of Guelph and an M. Sc. in forestry from Lakehead University. Lisa is responsible for coordinating newsletters, annual reports, workshops, displays, and public education programs relating to the VMAP.

Lisa replaces Dorothy Gillmeister, who filled this job on an acting assignment in 1991-92. We thank Dorothy for her contributions to the program.

Joanie Rudzki, Vegetation Management Secretary - Joanie was previously the receptionist/revenue receiving clerk at the Wawa district office. She joined the OFRI in 1990 as the Administration Clerk Steno and moved into the VMAP secretary position in 1991. Joanie assists VMAP staff in administration and typing, and acts as a liaison to other government agencies, universities, and the private sector.

Christine Hollstedt, VMAP Forester, NWRSTTU - Chris graduated with a B. Sc. in forestry from Lakehead University. She worked at the former NWOFTDU as a project forester for the black spruce program and the VMAP. Previously she worked for Abitibi-Price, Inc., Thunder Bay, as a forester on regeneration and vegetation management programs. Her main areas of interest are forestry, ecology, and range management. Chris is responsible for the VMAP at the new Northwest Region Science and Technology Terrestrial Unit (NWRSTTU).

Andrée Morneault, VMAP Program Leader, CRSTDU - Andrée received her B. Sc. in agriculture from MacDonald College of McGill University and her M. Sc. in forestry from the University of Toronto. For her masters thesis, she worked on developing a competition index for jack pine plantations in northern Ontario. For

the past year, Andrée has been working as a specialist-in-training with the Southern Ontario Forest Health Unit. Andrée will be running the VMAP for the new Central Region Science and Technology Development Unit (CRSTDU).

Dianne Othmer, VMAP Technician, CRSTDU - Dianne has been a timber technician in Kapuskasing district for many years and has recently been closely involved with the Survey of Artificially Regenerated Sites (SOARS) program. Dianne will provide technical support for the VMAP in the Central Region.

Susan Pickering, VMAP Forester, NEST - Sue comes to us from the management planning section of Timmins district. She graduated from University of Toronto with a B. Sc. in forestry. As well as working for forest industry, Sue worked as a private land forester in Toronto before going to Timmins. Sue is responsible for the VMAP projects initiated by the new Northeast Science and Technology (NEST) Unit.

Bruce Richard, VMAP Technician, NEST - Bruce has been seconded to the VMAP from Kapuskasing district where he was Lands Management Technician. He has a diploma in forest technology from Sault College and has a strong background in fire management. Bruce will provide technical support for the VMAP projects in the Northeast Region.

Silvia Strobl, Plantation Forest Specialist, STTU - Silvia was previously the hardwood program forester with the former Fast Growing Forests Technology Development Unit (FGF TDU), where she was responsible for the hardwood component of the VMAP, hybrid poplar tree improvement, hybrid poplar silviculture, and the development of a streambank biostabilization program using native shrubby willows. She has a B. Sc. and an M. Sc. in forestry from the University of Toronto. In the new Southern Technology Transfer Unit (STTU), one of Silvia's responsibilities will be delivery of the VMAP for the Southern Region.

In 1991-92, Ron Keane was responsible for the conifer component of the VMAP activities at the former FGF TDU. We thank Ron for his contributions to the program.

Forest Industry Cooperation

Cooperation from forest companies that have responsibility for managing forest vegetation on Crown land is vital to the success of the VMAP. Therefore, the Ontario Forest Industries Association and the Ontario Lumber Manufacturers Association were asked to participate in the development of the VMAP. Representatives from these organizations provided valuable input during development of the Prospectus.

A Memorandum of Agreement was developed for forest companies to formally participate in the VMAP. We thank **Jim Waddell, E.B. Eddy Forest Products, Ltd.,** for his help in writing this Agreement. Four companies requested cooperator status in the VMAP this year. We thank **Paul Jewiss, Boise Cascade Canada, Ltd.; Bill Roll, Canadian Pacific Forest Products, Ltd.; Jim Waddell, E.B. Eddy Forest Products, Ltd.;** and **Rob Tomchick, Quebec and Ontario Paper Company, Ltd.** for joining the VMAP. We look forward to working together to accomplish VMAP goals.

Industry cooperators have representation on the VMAP technical committee where they assist in prioritizing research, education, and field delivery needs related to forest vegetation management. They also identify forest industry's concerns regarding vegetation management issues and encourage transfer of VMAP research results to their field staff. In addition, industry cooperators participate as active partners in select research and field delivery projects on their forest management agreement areas.

ADAPTIVE RESEARCH

Adaptive research in the VMAP seeks to develop concepts, techniques, methods, tools, or products that are directly applicable to improving forest vegetation management. This effort involves three areas of investigation: 1) **treatment alternatives**, including the testing and refinement of manual cutting, grazing animals, mulches, prescribed fire, mechanical equipment, cover cropping, new herbicide application systems, and alternative silvicultural approaches; 2) **forest ecosystem responses**, including quantifying crop tree responses and wildlife habitat impacts of vegetation management; and 3) **forest models**, including growth and yield projection of crop tree responses following alternative vegetation management treatments. The following adaptive research projects were conducted this year:

Assessment of Vegetative Competition in Young Conifer Plantations

The objective of this study by **Dr. Blake MacDonald, OFRI**, was to develop better measures of vegetative competition and conifer seedling responses in young forests. Improved methods of vegetation assessment can assist in developing more effective timing and intensity of release treatment prescriptions. All remaining analyses were completed and three papers published this year.

The amount of vegetation cover on a fisheye photograph relative to the leaf area of the seedling explained up to 75% of the variation in current diameter increment for black spruce (Picea mariana (Mill.) B.S.P.) and jack pine (Pinus banksiana Lamb.) seedlings. A more operationally feasible index that also performed well (r^2 up to 62%) was a ratio of the sum of surrounding vegetation stem volumes (using one dominant competitor in each quadrant) to seedling stem volume. These indices can also be used for growth analysis and are applicable to container or bare root black spruce and jack pine seedlings.

A modified growth analysis technique permitted detailed comparisons of the absolute and relative growth rates among conifer species and stock types. While jack pine demonstrated greater absolute growth than black spruce under competition (Figure 3), it showed a greater reduction than black spruce in relative growth rate (Figure 4).

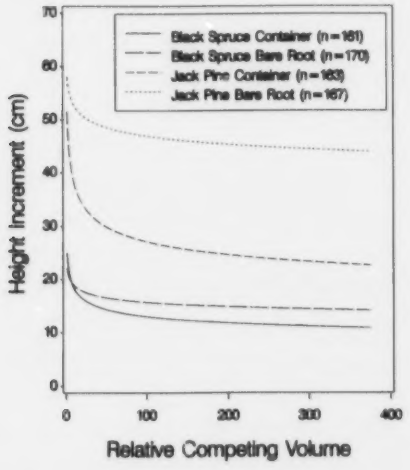
Black Spruce Container (n=161)
Black Spruce Bare Root (n=170)
Jack Pine Container (n=163)
Jack Pine Bare Root (n=167)
Height Increment (cm)
Relative Competing Volume

Figure 3. Absolute height increment of each species/stock type in response to non-crop competition.

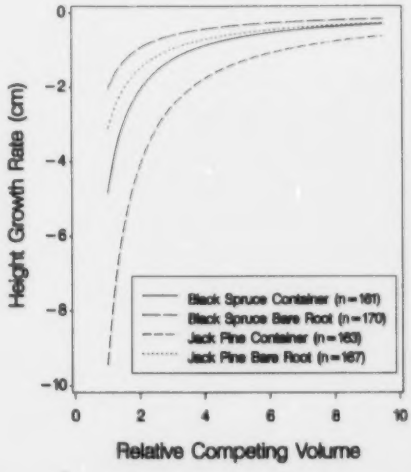
Black Spruce Container (n=161)
Black Spruce Bare Root (n=170)
Jack Pine Container (n=163)
Jack Pine Bare Root (n=167)
Height Growth Rate (cm)
Relative Competing Volume

Figure 4. Relative height growth rate of each species/stock type in response to non-crop competition.

Mixedwood Successional Trends

This study by **Dr. Blake MacDonald, OFRI**, compared the abundance and diversity of woody and herbaceous vegetation developing after specific disturbance types (wildfire, harvesting, and mechanical scarification) on boreal mixedwood sites. This information will guide predictions of the vegetation control measures required to ensure the success of crop species on wildfire burns and scarified cutovers.

All of the planned data entry and most of the statistical analyses were completed this year. For the scarified sites, preliminary results indicate that the abundance and diversity of plant species are at a maximum two to four years after scarification. Also, the abundance and diversity of vegetation are greater for moderate disturbances than for severe disturbances. For burned sites, abundance and diversity of vegetation peak about four years after disturbance. While species diversity is greater following a light burn than after an intense burn, the abundance of vegetation is greater following an intense burn.

During 1992-93, the analyses will be finalized and silvicultural implications will be reported. More information on this trial may be obtained from Blake MacDonald at 705/946-2981.

Treatment Efficacy Database

Effective vegetation management prescriptions require a thorough understanding of the efficacy and selectivity of the many vegetation treatment options. A cooperative project between **Dr. Bob Wagner, OFRI**, and **Dr. Bob Campbell, Forest Pest Management Institute**, seeks to improve knowledge in this area. Data on the ability of various types, rates, and timing of herbicides to control many forest plant species have been collected by the OMNR and the Eastern Canada Expert Committee on Weeds for over a decade. These data, however, have not been compiled in a manner that can be easily used by forest managers when making vegetation management prescriptions.

The purpose of this project is to analyze some eighty datasets that have been collected across Ontario by the OMNR and summarize data collected by various researchers for the Eastern Canada Expert Committee on Weeds. Many of the OMNR datasets include vegetation measurements on permanent plots for two to five years. These data will be integrated into a single document describing the efficacy and selectivity of many available vegetation management options. When completed some time next year, this document will be the first of its kind in eastern Canada and the eastern U.S. Future plans call for using these data in the development of a knowledge base for a computerized decision-support system. For more information on this study, contact Bob Wagner at 705/946-2981.

Spray Drift Reduction Study

A collaborative study with six research agencies from across Canada compared the performance of three aerial spray delivery systems attached to fixed-wing aircraft. The research team was lead by **Mr. Chris Riley, Research and Productivity Council of New Brunswick,** and included scientists from the **National Research Council, Atmospheric Environment Service, Forest Pest Management Institute, University of New Brunswick**, and **Forest Protection Limited**. The primary interests of the researchers were quantifying on-site deposit and off-site movement of herbicide sprays and correlating deposit on vee-type foliage simulators with that on natural foliage of red raspberry (Rubus ideaus L.), aspen (Populus tremuloides Michx.), and red maple (Acer rubrum L.).

Twelve applications of a simulated spray were made from three Cessna 188 Ag Truck planes, equipped with either a: 1) Micronair AU 4000, 2)

D8-46 Hydraulic nozzle, or 3) Through Valve Boom (TVB) system. During testing, the Cessnas flew at 177 kph (110 mph) at either 15 or 30 m above ground, and deposit (canopy and ground) plus airborne mass (potential off-site movement) were quantified up to 600 m from the flight path.

Laboratory tests indicated that foliage simulators had similar capture efficiences as the broadleaf foliage. Field trials also gave acceptable results.

Differences in deposition percentages and airborne mass between 300 and 600 m were minimal. Figure 5 presents means for on-site deposit and airborne mass up to 600 m from the flight path.

Conclusions from this study are applicable to fixed-wing aircraft flying at approximately 177 kph. They include:

(1) The TVB produced the least off-target movement, when compared with the other systems (a significant fraction of the spray emitted from the AU 4000 was still airborne at 600 m from the flight line).

(2) The swath width of the TVB system was narrower and less susceptible to off-target movement than those of the other two systems.

(3) Swath width and off-target movement increased with increasing application height and wind speed (Figure 6).

(4) As wind speed and/or aircraft height increased, total deposit decreased and the airborne mass increased. Since wind speed increases with the height above ground, if spray aircraft have to operate from a greater height due to uncut trees in harvested areas, both height and wind speed will increase, leading to greater off-target movement.

The biological implications of the variance in drift and deposit found in this study have yet to be investigated. Mr. Riley can be contacted at 506/452-8994.

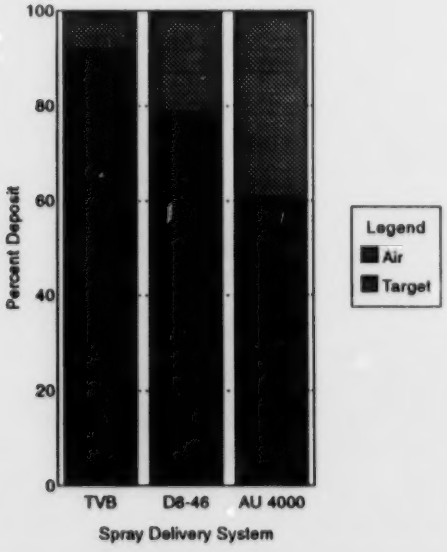

Figure 5. Average on-site deposit and off-target movement to 600 m from the flight path for three spray delivery systems flown at 177 kph.

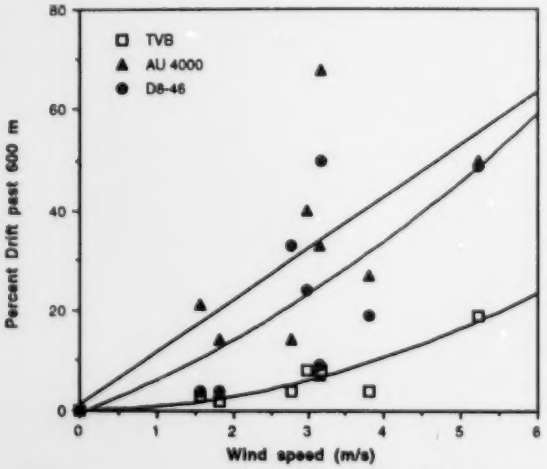

Figure 6. Off-site movement versus wind speed at 600 m from the flight path (bottom line - TVB, middle line - D8-46, top line - AU 4000).

REGIONAL PROJECTS

Tremendous support for the VMAP activities was provided by the new regional Science and Technology Units. The following describes adaptive research at these units. Figure 7 presents an overview of the trial locations.

Figure 7. Location of the 1991-92 VMAP field trials in Ontario.

NORTHWEST REGION

Manual Versus Chemical Release

A demonstration trial was initiated in 1984 in Geraldton district to compare the efficacy of Roundup® (active ingredient glyphosate) and 2,4-D herbicides as stump treatments (#4 in Figure 7). Various concentrations of stump-applied herbicide are being compared for aspen control. The trial was remeasured in 1991 by **Wayne Bell** and **Rob Whaley, NWOFTDU**.

Of ten plots, four were brushsawed and simultaneously stump-treated with Roundup® (356 g a.e./ha) at concentrations of 5, 10, 15, and 20 percent. Three plots were brushsawed and simultaneously stump-treated with 2,4-D (600 g a.e./l) at concentrations of 10, 20, and 30 percent. One plot was cleared using brushsaws without herbicide, one plot was cleared using sandvik hand cutting tools to produce a three-quarter cut, and one plot remained as an untreated control. There were no replications. Brushsaw results could not be collected in 1991-92.

Roundup® applied at concentrations of 5, 10, and 15 percent and 2,4-D applied at 10 percent concentration appeared to be most effective in decreasing numbers of aspen stems. 2,4-D as a stump treatment did not reduce stem numbers, but was most effective in reducing the height growth of the sprouts.

The use of brushsaws and sandviks (without herbicide application) reduced the number of stems during the treatment season, but prolific sprouting the following year increased the number of stems on those plots above pre-treatment levels. All the chemical treatments, as well as the sandvik only treatment, were effective in controlling (not eliminating) aspen growth. A technical note on this trial is available from Chris Hollstedt at 807/939-2501.

Nipigon Ground Release Methods Comparison

Eight ground release treatments are being compared in a trial established by **Bill Towill, NWOFTDU**, and **Dr. Bob Wagner, OFRI**, in Nipigon district in 1990 (#3 in Figure 7). The purpose is to document the response of crop trees and non-crop vegetation to treatment, as well as evaluate the application procedures and operational limitations of the treatments.

Treatments include an untreated control, reel and hose broadcast application, Ezject capsule herbicide injection, thin-line basal spray, brushsaw with Enso herbicide applicator (Figure 8), Spotgun herbicide applicator, complete vegetation removal, and backpack sprayer waving-wand application. Vision®, Velpar®-L (active ingredient hexazinone) and Garlon® (now Release®) (active ingredient triclopyr) were applied at various rates depending on the method of application.

Figure 8. Brushsaw with Enso herbicide applicator being used in a trial comparing ground release methods near Nipigon. (Photo by Len Godwin)

First-year results indicated significant increases in crop tree diameter at 15 cm for the Thin-line basal spray and complete vegetation removal plots over untreated control plots (Figure 9). An interim report is available from Chris Hollstedt at 807/939-2501.

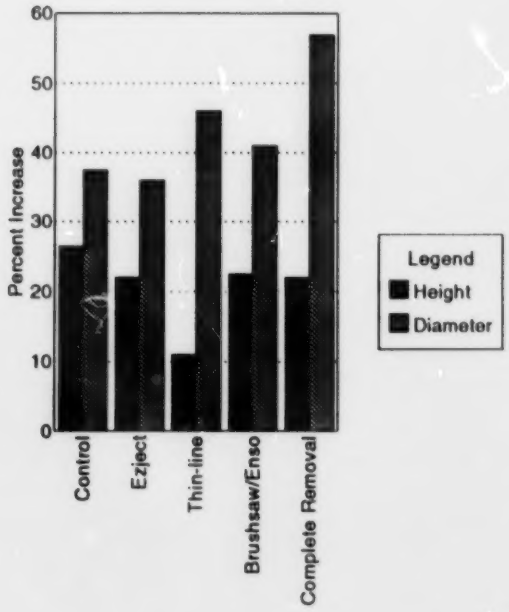

Figure 9. Percent height and diameter increase for black spruce in Nipigon ground release methods comparison trial after the first year.

Susceptibility of Competing Species to Vision® Herbicide

Three field studies were initiated in 1990 by **Wayne Bell** and **Bill Towill, NWOFTDU**, to determine the susceptibility of black spruce, blue-joint grass (Calamagrostis canadensis (Michx.) Beauv.), jack pine, and red raspberry to Vision® (active ingredient glyphosate) (#1 in Figure 7). Vision® was applied at two rates (1.1 and 1.7 kg a.e./ha) at two-week intervals from mid-July to mid-September.

Percent cover for the competing species and crop tree size were recorded prior to treatment. Post-treatment responses of conifer crop trees and competing vegetation were assessed in 1991. Spruce volume growth was increased most by sprays between August 15 and September 10. Jack pine responded best to sprays applied between July 31 and August 28. Vision® applied from August to mid-September, following seed dispersal but prior to senescence, appears to be most effective in reducing blue-joint grass. Best control of raspberry regrowth was obtained with late July to early September applications.

Phenological characteristics of blue-joint grass and red raspberry (see project summary below) were also observed during the course of the treatments. Greenhouse studies were conducted by **Dr. Azim Mallik, Lakehead University**, to determine treatment effects on the shoot regrowth potential of blue-joint grass rhizomes. Rhizome activity of blue-joint grass was reduced significantly by Vision® applied in late August regardless of rate.

First-year results indicate that 1.1 kg a.e./ha of Vision® can be used to control both blue-joint grass and red raspberry with minimal damage to conifer crop trees. An interim report on this trial is available from Chris Hollstedt at 807/939-2501.

Effect of Vision® Herbicide on Red Raspberry Seed Viability

A field trial initiated by the NWOFTDU in 1990 (see above), to examine the effects of Vision® application rate and timing on percent kill of red raspberry in a jack pine plantation near Nipigon, Ontario, was expanded in 1991 to include a study on the viable seedbank. **Christine Chourmouzis** and **Dr. Andy Gordon, University of Guelph**, set out to determine the effect of rate and timing of Vision® application on the raspberry seedbank. In theory, herbicide application could affect seed

emergence and production if the application occurred during a critical period of seasonal development.

In 1990, Vision® was applied using a CO_2 pressurizing backpack sprayer at two rates (1.1 and 1.7 kg a.e./ha) at five times (July 21, July 31, August 15, August 28, and September 25). The ten treatments, replicated three times, were randomly assigned to 20 by 40 m plots.

In the fall of 1991, four 15 cm diameter soil samples were collected from the top 10 cm of each plot. The samples were sorted to remove rhizomes and roots, then transferred to 10 cm pots in a greenhouse at the University of Guelph. Counts of germinants were made bi-weekly over a four month period and totalled for each plot.

Regression analysis indicated the red raspberry seedbank was not significantly affected by the rate or timing of Vision® application. Copies of the interim report are available from Lisa Buse at 705/946-2981.

Conifer Growth Response to Velpar®L Herbicide

This project was undertaken by **Bill Towill, NWOFTDU**, and **Ago Lehela, OFRI**, to test the efficacy of Velpar®-L as a site preparation treatment on coarse loamy soils (#2 in Figure 7). Data have been collected and compiled over five years and a technical report will be completed in 1992-93. Differences in crop tree mortality, tree height and diameter increment, and non-crop vegetation will be discussed in the report. For more information on this trial contact Ago Lehela at 705/946-2981.

NORTHEAST REGION

Sheep For Forest Vegetation Management

The objective of this project was to investigate the potential benefits of grazing sheep in forest plantations to control vegetation. **Tim McCarthy, NEST**, organized a small demonstration trial using 51 sheep that was carried out for 23 days in Chapleau district in August of 1991 (#5 in Figure 7). Two shepherds were contracted to provide 24-hour supervision to the sheep on a 3.5 hectare brushy three-year-old jack pine plantation (Figure 10). This trial was the first of its kind in northern Ontario forests.

Preliminary results indicate that an average of 50% of the above-ground biomass on the block was removed by the sheep. Had the shrubs and trees on the site been shorter (more accessible to the sheep), the sheep would likely have removed more.

Figure 10. Sheep grazing in a northern Ontario trial. (Photo by Bob Wagner)

Crop tree damage was low (1% grazed terminals and 3% trampled), and mainly occurred on access routes. The sheep showed preferences for certain plant species. Highly palatable species included young grass, clover (Trifolium spp.), pin cherry (Prunus pensylvanica L.f.), mountain ash (Sorbus americana (Marsh.), honeysuckle (Lonicera spp.), large-leaved aster (Aster macrophyllus L.), bindweed (Convulvus arvensis L.), serviceberry (Amelanchier spp.), vetch (Vicia americana Muhl.), and aspen. Low palatability species included blueberry (Vaccinium spp.), sweetfern (Comptonia peregrina (L.) Coult.), and yarrow (Achillea spp.).

Sheep are not a panacea for all brush control problems, but can be used effectively in the first few years of plantation establishment on select sites. The NEST will be continuing this trial in 1992-93. Further information can be obtained from Sue Pickering at 705/267-7951 or Tim McCarthy at 705/360-8214.

TRH-150 Brush Cutter

This trial was designed to examine the suitability and applicability of the TRH-150 brush cutter to sites in the Northeast Region (#6 on map). The brush cutter was designed for cutting and clearing operations, and is mainly used mounted on the boom of an excavator for right-of-way and roadside brushing. **Ecological Services for Planning** was contracted to evaluate the brush cutter and to test the manufacturer's claims that undesirable vegetation, shredded and dispersed across the site by the cutter, will slow the growth of the remaining undesirable vegetation.

A ten hectare area was treated in 1991 using the TRH-150 brush cutter mounted on a tracked John Deere 790 excavator. The machine was successful in reclaiming backlog sites in that it removed brush and provided access for planting. The mulch may or may not retard herbaceous growth depending on its thickness (which is site dependant). It will not retard shrub recovery because 15 - 30 cm stumps are left from which sprouting can occur. The head of the brush cutter cannot be lowered to remove more of the stumps because of the hazard of damage from rocks.

Treatment costs were high at about $1200/ha. These costs may vary by site condition and operator experience. A report on this trial will be available in 1992-93. More information is available from Sue Pickering at 705/267-7951 or Sue Parton at 705/272-4365.

Research Plot Maintenance

All trials in the region were assessed for their potential to be maintained and remeasured as part of the VMAP. Each district was canvassed by **Sue Parton, Cochrane District**, and a report compiled summarizing trials worthy of remeasurement. Of the fourteen projects reviewed, six had potential for remeasurement or as demonstration areas. Among these are an aerial versus hand tending trial, and a chemical site-preparation versus prescribed burn trial. The latter will be reassessed and reported on in 1992-93. The other potential projects still require closer study to determine the degree of maintenance required. A report on all the projects found to have potential for maintenance or remeasurement will be available in 1992. More information can be obtained from Sue Pickering at 705/267-7951 or Sue Parton at 705/272-4365.

CENTRAL REGION

Chemical Versus Mechanical Site Preparation

A cooperative effort between **Derrick Yorke** and **Kelvin Reid, Sudbury District**, and **Andy Mutchmor, Central Ontario Forest Technology Development Unit (COFTDU)**, is addressing the following questions: 1) which rates of Vision® herbicide best satisfy integrated re-

source management objectives; 2) will crop trees on Vision®-treated areas grow as well as those on mechanically or mechanically/chemically treated areas, and if so what rate is best; 3) are there benefits associated with mechanical/chemical treatments; 4) will trees survive and grow satisfactorily on untreated areas; 5) how do the treatments affect moose/deer browse (availability and species composition); 6) does the Algonquin airblast sprayer perform satisfactorily; and 7) which rates of Vision® are most effective for controlling the unwanted vegetation?

The trial consists of four blocks, each with seven treatments; four chemical treatments (Vision® at 0.5, 1.1, 1.6 and 2.1 kg a.e./ha), one mechanical treatment (Donaren power disk trencher), one mechanical/chemical treatment (disk trencher and Vision® at 1.78 kg a.e./ha), and an untreated control (#7 in Figure 7).

Baseline data on vegetation abundance was collected in August 1990 and site-preparation treatments began in September 1990. White spruce (Picea glauca (Moench) Voss) was planted in 1991. The first assessment was done in 1991 and will continue through 1995. Data are currently being analyzed. Further information can be obtained from Andy Mutchmor at 705/474-5550.

Manual Versus Chemical Tending

A demonstration area was established in 1989 by **Andy Mutchmor, COFTDU**, to observe the growth and survival of crop and non-crop trees in red pine (Pinus resinosa Ait.) and white pine (Pinus strobus L.) plantations following brushsaw and chemical (Vision® at 1.4 kg a.e./ha) tending (#8 in Figure 7).

First-year results indicate that Vision® herbicide reduced the average number of woody stems in both red and white pine plantations more than did manual tending (Figure 11), but both Vision® and manual tending were effective in reducing the

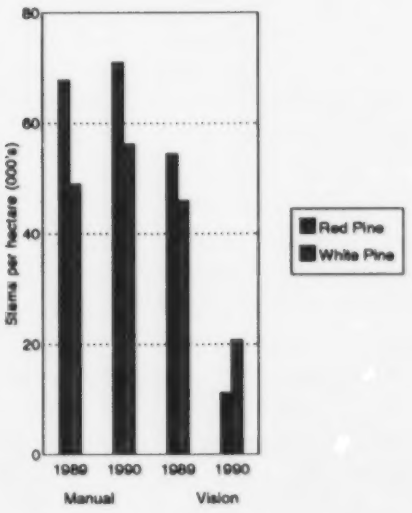

Figure 11. Amount of woody vegetation in a red and a white pine plantation one season after manual and chemical tending.

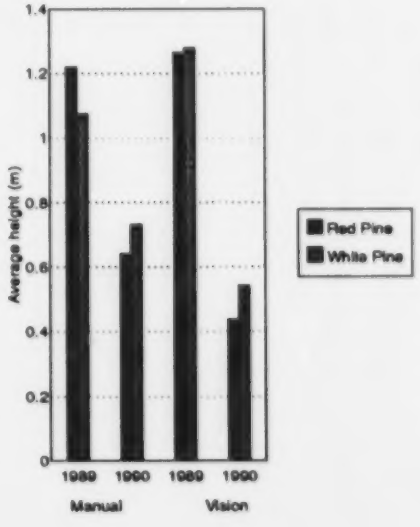

Figure 12. Height of woody vegetation in a red and a white pine plantation one season after manual and chemical tending

height of competing vegetation (Figure 12). Further information can be obtained from Andy Mutchmor at 705/474-5550.

Vegetation Management in Pine and Tolerant Hardwoods

The tolerant hardwood and pine working groups are significant cover types for timber and wildlife management in the forests of the Central Region. The purpose of this project is to lay the groundwork for advancements in vegetation management practices in these working groups.

For pine, a comprehensive set of trials were planned in conjunction with **Aviation and Fire Management, OMNR; Petawawa National Forestry Institute**; and **FORINTEK**. Site and treatment selections were made. Harvesting treatments will include no harvest, shelterwood harvest at half-crown spacing, and shelterwood harvest at two-crown spacing. Cultural treatments will include no treatment, prescribed fire, mechanical, chemical, and combined chemical/mechanical site-preparation. A portion of each treatment will be planted with white pine container stock. The trial area has been mapped using the Algonquin Region forest ecosystem classification system.

For hardwoods, extensive consultations with field clients were undertaken and a list of concerns prioritized. Project proposals relating to the role of prescribed fire in red oak (Quercus rubra L.) and yellow birch (Betula alleghaniensis Britt.) regeneration have been developed for 1992-93. Further information on these trials may be obtained from Fred Pinto and Brian Batchelor at 705/474-5550, Paul Ward at 705/945-5780, or Rob McAlpine and Mike Weber at 613/589-2880.

Algonquin Region Hemlock Regeneration

Hemlock (Tsuga canadensis (L.) Carr.) is a principal winter cover species for wildlife and is considered an indicator of species diversity. It is very difficult to regenerate hemlock without proper management of the overstory and control of associated vegetation. This trial is being undertaken by **Stan Visilauskas**, Ph. D. candidate at **Queen's University**, to determine the best approaches for successful hemlock seedling establishment in the understory. In 1991, 182 temporary sample plots were established in Algonquin park. Data on site conditions (soil and vegetation) were collected and analyzed. Data collection will be completed in 1992-93 and a report prepared. Further information on this trial can be obtained from Fred Pinto or Brian Naylor at 705/474-5550 or from Mike Wilton at 613/637-2780.

SOUTHERN REGION

Vegetation Management for Hardwoods in Southern Ontario

The following series of trials are testing a variety of materials, the costs of which vary greatly (Figure 13):

Mulches:

Brush Blankets® are 1 m^2 mulches made of 2 mm thick, green polyethylene and are intended as soil-warming, moisture-conserving, weed-reducing barriers around seedlings.

Thermats® are just less than 1 m^2 mulches made of green-brown polypropylene and have similar characteristics and functions as brush blankets®.

Tree Rings® are 1 m in diameter and consist of straw mulch glued to a sheet of filterpaper. They block sunlight but allow water to penetrate.

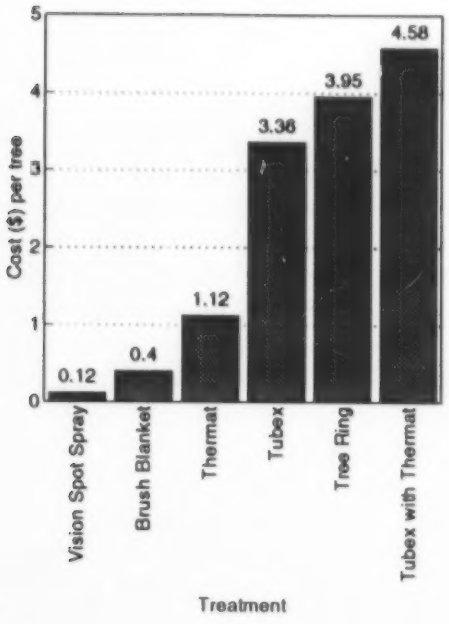

Figure 13. Per tree cost of alternative vegetation management treatments for southern Ontario hardwood regeneration.

Shelters:

Tubex® tree shelters are translucent, cylindrical plastic tubes that are placed over hardwood seedlings to provide an improved growing environment. They provide physical support, higher relative humidity, increased temperatures, protection from wind, and protection from girdling, clipping, and browsing by animals (Figure 14). They were developed in the U.K. and have not been extensively tested in Ontario's climate.

Tubex®/Mulch Trial with Black Walnut

This trial, reported on by **Silvia Strobl, STTU**, and established with the **Rideau Valley Conservation Authority**, compares survival and growth of black walnut (Juglans nigra L.) seedlings treated with: Brush Blankets®; Tubex® tree shelters with Thermat® mulch; Tree Rings®; and Vision® spot spray (#14 in Figure 7). Treatments were applied at the beginning of the second growing season, and seedlings were measured at the end of the second growing season.

Significant height growth differences were observed in black walnut seedlings treated with a combination of Tubex® shelters and Thermat® mulch as compared to other treatments. Tubex® plus Thermat® treated seedlings had a mean height of 1.4 m (versus 0.34 m for the Vision® treatment). A similar trial with white ash (Fraxinus americana L.) found no significant benefit associated with this or any other treatment (see project summary below). Height growth of the Tree Ring® treated seedlings was significantly greater than that of the Brush Blanket® treated seedlings. Basal diameter did not respond to any of the treatments. An interim report can be obtained from Silvia Strobl at 613/342-8524.

Figure 14. Hardwood planted with Tubex® tree shelter and Thermat®. (Photo by Silvia Strobl)

Tubex®Trial with Black Walnut

This trial, reported on by **Barb Boysen, STTU**, and established in cooperation with **Napanee District**, set out to determine the effects of Tubex® tree shelters on the establishment and growth of black walnut on an old field site (#13 in Figure 7).

Black walnut seedlings were planted and protected with 1.8 m high Tubex® shelters or left unprotected (control). Each treatment was replicated four times, for a total of eight plots with 10 trees per plot. The seedlings were measured at the end of the second growing season.

Mean height of sheltered black walnut trees (62.9 cm) was greater than controls (46.5 cm). The trees suffered little to no browsing damage. An interim report can be obtained by contacting Silvia Strobl at 613/342-8524.

Tubex®- Underplant Trial with White Ash

In this trial, reported on by **Danelle Harris, STTU**, and established with **Tweed District**, is attempting to: 1) re-establish and increase the white ash component in a tolerant hardwood selection cut, and 2) investigate the effect of Tubex®on the establishment of white ash in an underplant situation (#9 in Figure 7).

Six to eight white ash seedlings were planted at 2 m^2 spacing in eight randomly selected blocks in openings on a site which had been selection cut the previous winter. Tubex®shelters (1.5 m high) were placed over half the seedlings three days after planting, the other half (controls) were left as planted. There were three to five replications of each treatment within each block.

Statistical analysis showed no establishment or growth benefit associated with Tubex®shelters for white ash seedlings after the first growing season. So far there has been little deer or hare damage and shelters have not affected susceptibility to frost damage. An interim report can be obtained from Silvia Strobl at 613/342-8524.

Tubex®Mulch Trial with White Ash

This trial, reported by **Danelle Harris, STTU**, and established in cooperation with the **Rideau Valley Conservation Authority**, seeks methods of enhancing white ash survival and growth on an old field site (#15 in Figure 7).

Treatments in this trial included: Brush Blankets®, Tubex® shelters with Thermat® mulch; Tree Rings®, spot spray with Vision® herbicide; and an untreated control. Each treatment was applied to nine trees per plot and replicated three times.

Tubex® tree shelters with Thermats® and the Brush Blankets® increased ash height growth after the first growing season when compared with control and Vision® spot treatments. An interim report is available from Silvia Strobl at 613/342-8524.

Tubex® Trial with Red Oak

A cooperative trial with **Barb Boysen, STU**, and **Napanee District**, studied the effects of Tubex® tree shelters on the establishment and growth of red oak on an old field site (#12 in Figure 7).

The treatments included: 1) Tubex® shelters (1.8 m high) and vegetation control; 2) Tubex® shelters and no vegetation control; 3) vegetation control only; and 4) untreated control. Each treatment had four replicates, for a total of 16 plots with 10 trees per plot in the trial.

After two years, mean height of Tubex®sheltered trees (56.9 cm) was significantly greater than that of the trees on untreated control plots (42.8 cm), but height differences may have been the

result of rabbit browsing on the controls rather than the growth enhancing effects of the Tubex® shelters. The mean basal diameter of trees on untreated control plots (7.4 mm) was significantly larger than sheltered trees (5.9 mm). The variability in growth among sheltered trees demonstrates that the shelters are no substitute for high quality stock, good planting techniques, or vegetation management.

Based on preliminary results, and considering the expense and labour involved in establishing Tubex® shelters, it is recommended that Tubex® shelters not be used operationally on red oak until longer-term results are available. An interim report is available from Silvia Strobl at 613/342-8524.

Tubex® Silver Maple Trial

The purpose of this trial by **Barb Boysen, STU**, and **Cornwall District**, was to determine the effects of Tubex® tree shelters on the establishment and growth of silver maple (Acer saccharinum L.) on an old field site (#16 in Figure 7).

The trial consisted of five Tubex® and five untreated control plots of 12 trees each, randomly located over the site.

Tubex® protected trees had greater height growth (150 cm) than untreated control trees (130 cm) after two years, but most of this difference occurred during the first year. After two years, basal diameter for Tubex® protected trees was 12.9 mm, while untreated control tree diameter averaged 22.3 mm. Sheltered trees are taller, but trees on untreated control plots are growing well and seem healthier and more vigorous. Frost appears to be a factor limiting the successful use of Tubex® shelters with silver maple in eastern Ontario. An interim report can be obtained from Silvia Strobl at 613/342-8524.

Cover Cropping in Strips for Hardwood Plantation Establishment

Cover cropping is the deliberate establishment of non-crop vegetation to minimize invasion by more competitive plants, create forage for grazing animals, protect bare soil, or fix atmospheric nitrogen. There is currently little knowledge about the use of cover crops as an alternative forest vegetation management technique in Ontario.

The objectives of this cooperative trial between **Silvia Strobl, STTU**, and **Chatham District** (#10 in Figure 7) were to gain operational experience with strip seeding between rows of newly established hardwood trees and to evaluate the potential of several different species of cover crops in southern Ontario(Figure 15). In 1991, a cover crop trial was established in a two-year old green ash (Fraxinus pennsylvanica Marsh.) plantation with five species (sweet yellow clover (Melilotus officinalis (L.) Lam.), sorghum (Sorgum halepens (L.) Pers.), rye grass (Hordeum

Figure 15. Glyphosate strip spray of an established red clover cover crop. (Photo by Silvia Strobl)

jubatum L.) and white clover (Trifolium repens L.) mix, and sorghum and white clover mix). Although the trial was sown later than optimum (July), the equipment modifications required to facilitate between-row seeding were completed and the operational experience will benefit future trial efforts in 1992-93. For example, the variety of sorghum used established well but was too tall. A shorter variety will be used in future. More information can be obtained from Silvia Strobl at 613/342-8524.

Gromax®- White Pine Container Outplanting Trial

The objectives of this trial reported by **Barb Boysen, STTU**, and established by **Tweed District**, were: 1) to determine if a controlled release fertilizer (Gromax®), applied at planting, increases the growth of white pine container seedlings, and 2) to determine if the growth response is sufficient to reduce or eliminate the need for chemical tending. Gromax®is a controlled release fertilizer containing nitrogen, phosphorous, and potassium, plus moisture-absorbing gel, enclosed in a small biodegradable gauze bag (similar to a large tea bag).

Six blocks were randomly located across the site, and three plots (untreated control, Gromax® 2, Gromax® 4) were located within each block. Both Gromax® formulations are for dry sites but Gromax® 4 is for brushy areas. Twenty-five white pine per plot were planted at 2 m spacing with Pottiputki planting tubes. In the fertilizer plots, a Gromax® bag was dropped through the Pottiputki shaft before the seedling.

Although the Gromax® 2 treatment led to greater diameter growth in the pine after two years, no significant benefit was associated with the Gromax® treatment. Pine on untreated plots consistently outgrew pine receiving the Gromax® 4 treatment. An interim report can be obtained by contacting Silvia Strobl at 613/342-8524.

Tolerance of White Pine to Herbicides - Ten Year Results

This trial involved remeasurement of two trials established by the Brockville District. White pine planted at 1 x 1 m were released using a number of different herbicides (simazine, amitrole-T, Sinbar®(active ingredient terbacil), and mixtures of these herbicides). The data were collected in 1991 by **Ron Keane, STTU**. Preliminary results indicate no differences between treatments. In general, bareroot stock outperformed container stock. Because the seedlings were planted at such close spacing, crown closure had already occurred; therefore, intraspecific competition may be overriding any other treatment effects. A report on this trial will be completed in 1992-93. Further information can be obtained from Silvia Strobl at 613/342-8524.

FUNDAMENTAL RESEARCH

Fundamental research in the VMAP is directed at increasing our basic understanding of the sciences that support the practice of forest vegetation management. VMAP fundamental research focuses on: 1) **ecosystem dynamics**, including advancing our theoretical and empirical understanding of forest ecosystem processes and impacts related to vegetation management practices; 2) **biological control**, including developing the use of fungi, viruses, insects, bacteria, allelopathic plants, and natural phytotoxins for vegetation management; and 3) **the social interface**, directed at gaining a better understanding of the social forces shaping forestry practices and identifying what vegetation management methods the public finds acceptable.

Government, private, and university research organizations across Canada are participating in our fundamental research efforts. A new agreement established with the Agricultural Research Institute of Ontario (ARIO) this year will help coordinate the VMAP fundamental research efforts in future years. The ARIO provides a long history of excellence in coordinating agricultural and veterinary research in Ontario, and provides the VMAP access to a network of leading scientists throughout Ontario and elsewhere.

The following fundamental research projects were supported by the VMAP during 1991/92:

Ecosystem Dynamics

Increased understanding of ecosystem processes and impacts associated with forest vegetation management is vital to improving practices. Ecosystem dynamics research focuses on ecological interactions, process models, and theory related to vegetation management principles and practice.

One major study was initiated in the area of ecosystem dynamics this year:

Environmental Impacts of Prescribed Fire Compared with Mechanical Techniques for Site Preparation

Dr. Mike Weber, Petawawa National Forestry Institute, initiated an experiment designed to compare the effects of varying prescribed fire intensities with mechanical disk trenching and no treatment for site preparation. In addition to comparing planted red and white pine performance, the nutrient use efficiency of seedlings, soil impacts, and patterns of vegetation recovery will be examined. The treatments were all successfully applied during the summer of 1991. Pre- and post-treatment soil samples were collected to evaluate short-term nutrient and compaction impacts on the soil. Analysis of these samples is now being conducted. Pine seedlings have been reared and will be planted in 1992. Microenvironmental instrumentation to measure soil temperature, soil moisture, and light will also be installed during the summer of 1992. Part of the vegetation recovery work will include assessment of biodiversity and ecosystem resilience/recovery rates following these treatments. Look for future VMAP reports on development of this study. Dr. Weber can be contacted at 613/589-2880 for more information.

Biological Control

Biological methods offer an entirely new technology for managing forest vegetation. Biological control research in the VMAP is being coordinated by the **Biological Control of Competing Vegetation Research (BICOVER)** network. BICOVER is centred at the Forest Pest Management Institute in Sault Ste. Marie and is being led by **Dr. Dean Thompson**. This network brings together researchers from across Canada who are working on biological control methods for forest vegetation.

Three biological control projects were supported by the VMAP through the BICOVER network this year:

Bialaphos: A Promising Natural Phytotoxin for Red Raspberry and Kalmia Control

Research at **Laval University** by **Dr. Robert Jobidon** is testing a new biorational method of controlling red raspberry and other forest plant species. Bialaphos is a natural phytotoxin (phosphinothricin) derived from a specific strain of Streptomyces bacteria. Currently marketed as a herbicide in Japan, Bialaphos is one of the most promising biological control methods for forest use. Previous work by Dr. Jobidon has shown that Bialaphos is effective at controlling red raspberry (Can. J. For. Res. 1991 21:489-497) and Kalmia (Kalmia angustifolia L.) (North. J. Appl. For. 1991 8(4):147-149). Bialaphos is most effective when applied from late July through late August at from 2.0 to 2.5 kg a.i./ha.

The work being conducted for the VMAP is examining the tolerance of four conifer species (black spruce, white spruce, red pine, Norway spruce (Picea abies (L.) Karst.) to Bialaphos. Previous results have shown that black spruce is not significantly injured by Bialaphos at the rate and times when it is most effective on the target species. Preliminary results from this study indicate that the four conifer species can be adversely affected by Bialaphos depending on the rate and timing of application. Red pine has proven to be the most susceptible, followed by Norway spruce, black spruce, and white spruce. Final results will be available late next fiscal year. For more information on this study, Dr. Jobidon can be contacted at 418/643-7994.

Control of Canada Blue-joint Grass with the Fungus Bipolaris

Dr. Glen Sampson from **Nova Scotia Agricultural College** has been investigating the use of natural phytotoxins derived from the fungal pathogen Bipolaris sorokiniana for controlling Canada blue-joint grass. Blue-joint is a severe competitor that limits reforestation success across Ontario and the rest of Canada. Results from a series of experiments conducted by Dr. Sampson and his associates this year are quite promising. It appears that Bipolaris is capable of producing phytotoxic compounds that can selectively affect grasses (Figure 16). Blue-joint was found to be quite susceptible to these natural toxins, which appear to be active at very low concentrations.

The toxin is fast acting, producing symptoms on blue-joint within 24 hours. It causes yellowing (chlorosis) and bleaching of the leaves similar to the triazine herbicides (such as simazine). Therefore, the toxins may act to block photosynthesis as do triazine herbicides. The specific toxin or complex of toxins produced by the fungus has not yet been identified. Future work will be directed at isolating these compounds. All work to date has been done in the greenhouse and needs to be expanded to the field.

The VMAP will be supporting future work with this fungus through the BICOVER network. Additional information about this research can be obtained by contacting Dr. Sampson at 902/893-6600, or requesting the progress report from Lisa Buse at 705/946-2981.

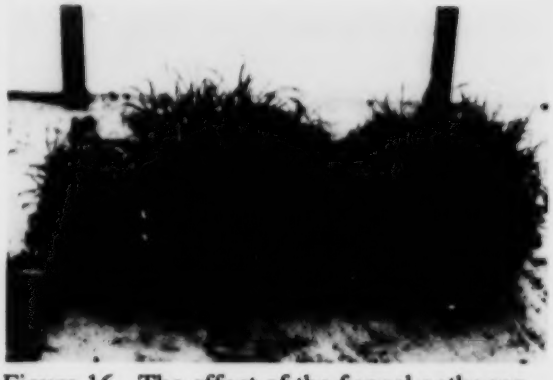

Figure 16. The effect of the fungal pathogen Bipolaris sorokiniana on foxtail barley, treated versus untreated strips.

Natural Phytotoxins as Biological Control Agents for Forest Weeds

Screening and isolation of natural phytotoxins requires bioassays that are good predictors of vegetation control. Other criteria of a good bioassay are that it be space efficient and relatively rapid. This project by **Dr. Bob Campbell, Forest Pest Managment Institute**, is developing bioassay procedures for three species which are major competitors of regenerating conifers in the Boreal forest: trembling aspen, red raspberry, and blue-joint grass. For a phytotoxin to effectively control these species, it must kill the roots as well as the tops, as all three sprout prolifically when cut.

In 1991-92, the following progress was made:

1) Propagation methods were established for each species. Aspen bioassay material is best propagated from seed, whereas blue-joint grass and raspberry are best propagated vegetatively. Plugs of sod are the best way to culture blue-joint grass. If established raspberry plants are cut back to the soil level periodically, they will produce numerous rooted shoots that can be subcultured.

2) Although all three species are hardy in the wild, they are prone to insects and diseases in the greenhouse. Appropriate insect control measures were developed.

3) The minimum size required for each of the three species to sprout when cut or top-killed with a phytotoxin was determined.

4) A production system was established to produce sufficient samples of bioassay material at monthly intervals. In addition to whole plant bioassays, this material will be used for bioassays of plant parts (e.g., leaf disk).

Vision®, the most widely used forest herbicide, is the standard against which new natural phytotoxins will be compared. The best dose-response relationships were obtained when the test plants were cut two weeks after spraying and regrowth measured four weeks later. The value of this approach to detect efficacy factors that are important under operational conditions was demonstrated in a test with phosphinothricin (the active ingredient of the natural phytotoxin Bialaphos) on aspen. Morning and evening applications produced identical top kill, but morning applications resulted in more regrowth. For further information contact Dr. Campbell at 705/949-9461.

Social Interface

No research was initiated in this area in 1991-92.

EDUCATION AND TECHNOLOGY TRANSFER

VMAP research is generating new information and technology. The benefits of the program can only be fully realized if this information is rapidly disseminated to forest managers for operational use. Compiling and synthesizing information from other sources into useful guides and literature reviews is also part of this effort. In addition, the general public must be made aware of new advances in vegetation management to foster public support of forest vegetation management practices. The VMAP education program focuses on: 1) an **Advanced Forest Herbicides Course**, 2) **professional education**, and 3) **public education**.

Advanced Forest Herbicides Course

A vital component of enhancing environmental protection while applying vegetation management treatments is ensuring that herbicide applicators, forest managers, and policy makers have a clear understanding of the benefits and risks associated with vegetation management. State-of-the-art training in all aspects of herbicide use and environmental protection is required to accomplish this goal.

Considerable work was done this year to begin an annual Advanced Forest Herbicides Course in Ontario (Figure 17). A collaborative agreement between the Ontario Forest Research Institute, Forest Pest Management Institute, and the University of Guelph was established to deliver the course. In 1991-92, course director **Craig Howard, Forest Pest Management Institute,** designed the curriculum and chose experts on various aspects of vegetation management from across North America to serve as instructors.

The course consists of six modules:

1) **Basic Pesticides** is a refresher on the basics of use and management of pesticides;

2) **Forest Herbicides** covers the products currently registered for use in forestry in Canada;

3) **Applications Technology** reviews the fundamentals of ground and aerial applications including hands-on sessions with equipment;

4) **Vegetation Management** provides a basic understanding of weed and crop ecology, and discusses vegetation management strategies;

5) **Environmental Impact** covers the effects of herbicides on the forest ecosystem; and

6) **Program Management** deals with the operational aspects of running a safe and effective herbicide program.

The modules will be integrated through a practicum that allows students to draw the information together by applying it to specific situations.

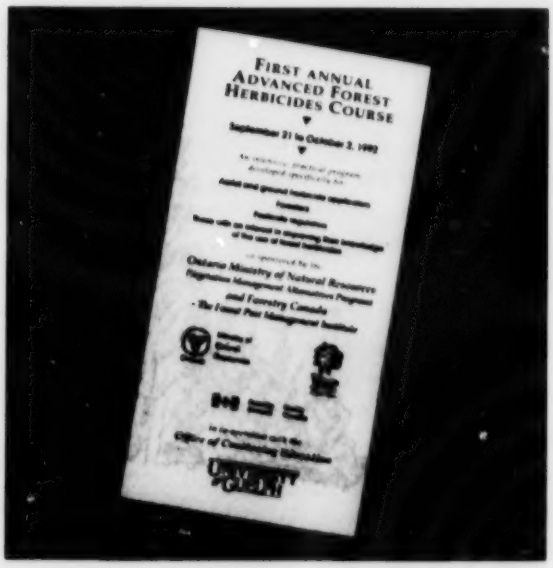

Figure 17. Brochure for the Advanced Forest Herbicides Course.

Course materials will be developed early in 1992. The first course will be held from September 22 to October 2, 1992 in Sault Ste. Marie. More information on the course can be obtained by contacting Craig Howard at 705/949-9461 or Lisa Buse at 705/946-2981.

Professional Education

Professional foresters both inside and outside the province were educated about alternative forest vegetation management practices through workshops, presentations and publications. Many publications were completed, including: three journal articles, nineteen technical reports/notes, eleven newsletter articles, fourteen progress reports, two papers in conference proceedings, and one workshop notebook. In addition, twenty-one lectures were presented to foresters around the province and elsewhere. These publications and presentations are listed at the end of this report.

Many of the VMAP professional education activities were delivered by the new regional Science and Technology Units. The following sections summarize the projects:

Autecology of Forest Vegetation

Effective management of forest vegetation requires a good working knowledge of the autecological characteristics of the major plant species. Since important plant species differ substantially among forest types across the province, three guides were developed based on a manual previously produced for the Northwest Region by Bell (1991)[1]:

Critical Silvics of Selected Species in Northwestern Ontario

Information from Bell (1991)[1] was summarized by **Lisa Buse** and **Wayne Bell, NWOFTDU**, into a pocket guide for field staff. Habitat requirements, reproductive characteristics, growth habits, response to disturbance, competitive mechanisms, and response to competition are described for crop and non-crop species in northwestern Ontario. Wildlife considerations are also featured. In addition to short written summaries, the information is provided in tabular form for quick cross referencing between species and site types. Additional species: white pine, bracken fern (Pteridium aquilinum (L.) Kuhn.), large-leaved aster, and reindeer lichens (Cladina spp.) were also included.

Information for the additional species was also summarized in the form of technical notes by **Lisa Buse, Chris Hollstedt**, and **Al Harris, NWOFTDU**, which were published in the spring of 1992 (referenced in publications list at the back of this report).

Autecology Guide for Great Lakes-St. Lawrence Region

The autecological characteristics of nineteen plant species relevant to the Great Lakes - St. Lawrence forest region were summarized by **Cathy Bentley** and **Fred Pinto, COFTDU**. The species include: mountain maple (Acer spicatum Lam.), alder (Alnus crispa (Ait.) Pursh. and A. rugosa (Du Roi) Spreng.), saskatoons and serviceberries (Amelanchier alnifolia Nutt., A. arborea (Michx. fil.) Fern., A. bartramiana

[1] Bell, F.W. 1991. Critical silvics of conifer crop trees and selected competitive vegetation in northwestern Ontario. For. Can. Ont. Region, Sault Ste. Marie, Ont./ Northw. Ont. For. Tech. Dev. Unit, Min. Nat. Resour., Thunder Bay, Ont. COFRDA Rep. 3310/ NWOFTDU Tech. Rep. 19. 177p.

(Tausch) Roem., A. humilis Wieg., A. laevis Wieg., A. sanguina Pursh. DC and A. stolonifera Wieg.), red-osier dogwood (Cornus stolonifera Michx.), viburnums (Viburnum acerifolium L., V. alnifolium Marsh., V. cassinoides L., V. edule (Michx.) Raf., V. lentago L., V. rafinesquianum Schultes, V. trilobum Marsh.), and bracken fern. This report will be published in 1992-93. Further information may be obtained from Fred Pinto at 705/474-5550.

Autecology of Non-Crop Plant Species on Old-Field Sites in Southern Ontario

A report summarizing the autecology of 28 non-crop species specific to old-field situations in southern Ontario will be finalized in 1992-93 by **Jim Louter, Maureen Kershaw,** and **Dr. Andy Gordon, University of Guelph**. Habitat requirements, reproductive characteristics, growth and development, phenology, response to disturbance, effects on crop trees, and uses by wildlife are described for each species. It will be published in loose-leaf field guide format. For more information contact Silvia Strobl at 613/342-8524.

Seedbanks in Northern Forest Ecosystems

Detailed knowledge of the role of seedbanks in northern Ontario is vital to understanding and predicting vegetation development on disturbed forest sites. A literature review was conducted by **Steve Hills** and **Dave Morris, OFRI,** to increase our understanding of seedbank dynamics, physiology of seeds in seedbanks, boreal and deciduous forest seedbanks, and seedbank dynamics in relation to succession. Recommendations for initiating a seedbank study in northern Ontario were made. Research needs include quantification of the seedbank for a variety of forest types, determination of conditions favouring the seedbank, and an examination of the process of seed incorporation into the seedbank. Once seedbanking patterns are established, the regeneration and competition potential can be predicted by site and disturbance type, thereby improving decision making for vegetation management. Final publication available from Lisa Buse at 705/946-2981.

Vegetation Management Strategies Workbook

A workbook initiated by the NWOFTDU, intended as a guide for developing a site-specific vegetation management strategy, was updated and expanded by **Bill Towill, Wayne Bell**, and **Al Wiensczyk, NWOFTDU**. It covers forest vegetation management objectives, crop tree silvics, autecology of non-crop plant species, plant interactions, successional pathways, and tools to determine if treatments are required, as well as an introduction to vegetation management tools, and the advantages and disadvantages of each. The workbook was used for workshops organized by the NWOFTDU in Dryden and Thunder Bay in 1991 and plans are underway for additional workshops in 1992.

Vegetation Management Alternatives Guide for Northern Ontario

The purpose of this project by **Wayne Bell, Jeff Kerley, and Michael McLaughlan, NWOFTDU**, is to compile published information and expert opinion pertaining to alternative vegetation management approaches into an easily used form. It will include information on the costs, advantages, and limitations of the vegetation management options currently available to forest managers. Some of the techniques covered include manual and mechanical methods (Figure 18). A technical report will be available in 1992-93. The information will also be incorporated into the Vegetation Management Strategies Workbook for use in future workshops. More information can be obtained from Wayne Bell at 705/946-2981.

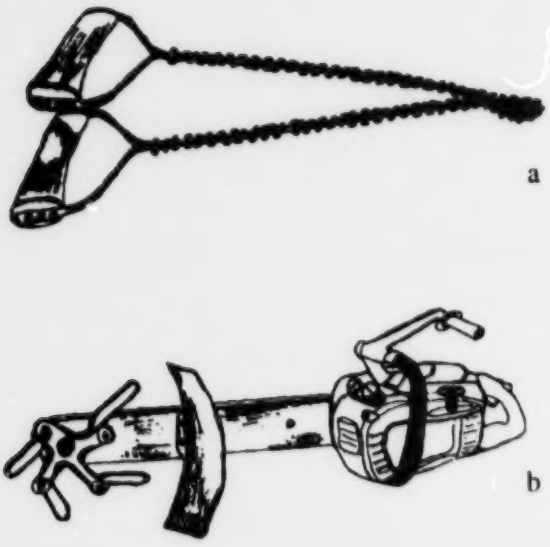

Figure 18. Some examples of manual and mechanical methods of vegetation control: a) chain girdler, and b) Hawk scalper.

Alternative Vegetation Management Techniques for Southern Ontario

This literature review by **Craig Robinson, STTU**, examines both establishment and tending technologies, with emphasis on old-field situations. Techniques discussed include mechanical, manual, mulches, and cover crops. A description of the method, its uses, effectiveness, advantages, disadvantages, cost, possible applications, users, and suppliers are included as well as an extensive literature cited section. This report is available from Silvia Strobl at 613/342-8524.

Technical Bulletins on Alternative Vegetation Management Techniques

The purpose of this project is to prepare a series of extension bulletins on alternative vegetation management technologies and effective herbicide application techniques for use by resource managers and the public in southern Ontario. To date, one note has been produced by **Ron Keene, STTU**, and **Betty van Kerkhof, Private Land Forestry, OMNR**, which reviews the steps required for successful planting, including: landowner objectives, site characteristics, establishment practices, post-planting considerations, and available technical advice. It is available in both french and english from Silvia Strobl at 613/342-8524. Additional notes are in preparation for publication in 1992-93.

Management of Black Spruce Advance Regeneration

A review of the literature on the management and use of black spruce advance growth was undertaken by **Rob Arnup, Ecologocal Services for Planning**, and **Dave Archibald, NEST**. In addition, data from forest ecosystem classification plots were analyzed to provide preliminary advance growth stocking estimates for each site type in northeastern Ontario.

Past research and operational trials have demonstrated that the management of advance growth can be a viable reforestation strategy. Where there is sufficient abundance and distribution of crop trees in the understory prior to harvest, careful harvesting techniques can preserve this component to help form the next forest. This approach can reduce the need for further silvicultural interventions such as site preparation, tree planting, and vegetation management.

This project will be described in technical reports and at field workshops in 1992-93. More information can be obtained from David Archibald at 705/360-8213.

Prescribed Fire Review

This project examines the potential for an increased use of prescribed fire as an alternative to herbicides in the Central and Southern Regions. Field visits were conducted across central and

southern Ontario and a literature review was undertaken to determine the current and potential applications of prescribed burning in vegetation, wildlife, and ecosystem management. A report by **Charlie van Wagner**, formerly with the fire research program at Petawawa National Forestry Institute, will be published in 1992-93. In addition to summarizing the applications of prescribed fire, the report will recommend a program for prescribed burn information and technology transfer to field staff. Additional information can be obtained from Alex Gardner at 705/474-5550.

Vegetation Sampling Methods for Southern Ontario

This literature review by **Craig Robinson, STTU**, examines the current work on competition indices and techniques for vegetation sampling with emphasis on technologies suited to southern Ontario conditions. The majority of information was drawn from studies in forest research and vegetation ecology.

The review discusses interspecific competition, measurement of competitive interactions, competition indices, quantifying competition, and sampling methods. It provides a discussion and summary with preliminary recommendations. The author proposes field testing the assessment methods in old fields at different times during the growing season to determine which is most accurate, efficient, and user-friendly. The report is available from Silvia Strobl at 613/342-8524.

Granular Herbicide Applicator Report

Combined mechanical/chemical site-preparation with a granular herbicide product reduces worker exposure and potential drift associated with broadcast aerial applications, as well as allowing for site-specific selection of areas requiring treatment within a block. The objective of this report by **Michael McLaughlan, NWOFTDU**, is to examine available manual, mechanical, and aerial granular herbicide applicators. In addition, the characteristics of Pronone®herbicide (active ingredient hexazinone), currently the only granular herbicide registered for forestry use, are described. The report will be published in 1992-93. Mike McLaughlan can be contacted at 807/939-2501.

Crop-Planning System on Vegetation Management

A crop-planning decision-support system is an interactive computer program that allows resource managers to examine a range of options with respect to the establishment and management of plantations for long-term planning. The vegetation management module is one of seven modules being developed by foresters across southern Ontario intended to improve red pine management planning on old-field sites. In addition to the biological optima, economic objectives can be evaluated using the system. The entire system is to be completed in 1992-93. Eventually, it will be expanded to include other crop species. More information can be obtained by contacting Silvia Strobl at 613/342-8524.

Public Education

Efforts to educate the public about vegetation management came in the form of a television news segment, two radio spots, and several newspaper articles on sheep grazing as a forest vegetation management tool. Efforts to search for alternatives were featured prominently in these reports. An article on the VMAP also appeared in "Forestry on the Hill", a publication about Canadian forestry issues for the federal legislature.

Work with several consultants on developing a public education strategy on forest vegetation management issues resulted in a three-phase proposal to develop a comprehensive education

program. This proposal will be initiated in the next fiscal year.

A poster display outlining the purpose and components of the VMAP was developed for use at conferences, workshops, etc., to increase awareness of the program.

PUBLICATIONS AND PRESENTATIONS

The following publications and presentations resulted from VMAP efforts this year:

Journal Articles

MacDonald, G.B. and G.F. Weetman. 1992. Functional growth analysis of conifer seedling responses to competing vegetation. For. Chron. 68: (in press).

Morris, D.M. and G.B. MacDonald. 1991. Development of a competition index for young conifer plantations established on Boreal mixedwood sites. For. Chron. 67(4): 403-410.

Wagner, R.G. and J.C. Zasada. 1991. Integrating plant autecology and silvicultural activities to prevent forest vegetation management problems. For. Chron. 67(5):506-513.

Technical Reports and Notes

Anonymous. 1991. Planning to establish a forest in open fields. Getting help and getting started. Ont. Min. Nat. Resour., Woodl. Ext. Notes, Ext. Circ. 1001. (also available in french)

Arnup, R.W. and D.J. Archibald. 1992. The management of black spruce advance growth in northeastern Ontario. Ont. Min. Nat. Resour., N.E. Sci. Tech. Unit, Tech. Rep. (in progress).

Bell, F.W., J. Kerley, and M. McLaughlan. 1992. Vegetation management alternatives: A guide to opportunities. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit, Tech. Rep. (in progress).

Buse, L.J. 1992. Critical silvics of white pine as related to vegetation management. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. TN-14. 12 pp.

Buse, L.J. 1992. Critical silvics of bracken fern as related to vegetation management. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. TN-16. 8 pp.

Buse, L.J. and F.W. Bell. 1992. Pocket guide to the critical silvics of selected crop and competitor species in northwestern Ontario. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit, Thunder Bay, Ontario. 138 pp.

Hills, S.C. and D.M. Morris. 1992. The function of seed banks in northern forest ecosystems (A literature review). Ont. Min. Nat. Resour., Ont. For. Res. Inst., For. Res. Info. Pap. No. 107. 25 pp.

Hollstedt, C. 1992. Critical silvics of large-leaved aster as related to vegetation management. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. TN-15. 8 pp.

Hollstedt, C. and A. Harris. 1992. Critical silvics of reindeer lichen as related to vegetation management. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. TN-17. 12 pp.

Louter, J.H., M. Kershaw, and A.M. Gordon. 1992. The autecology of competing non-crop vegetation on old field sites in southern Ontario. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Tech. Rep. (in progress).

MacDonald. G.B. 1991. A comparison of new proximity-based expressions of competing vegetation. Ont. Min. Nat. Resour., Sault Ste. Marie. For. Res. Rep. No. 126.

Mickle, R.E. and J.A. Arnold. 1992. Continuation of studies to examine the effects of aircraft parameters on deposit and drift of forest herbicides. Atmospheric Environment Service, Downsview, Ontario.

Picot, J.J.C., B.L. McLeod, and T.J. Chapman. 1992. Design and calibration of foliage simulators for herbicide spraying. Dept. Chemical Engineering, Univ. New Brunswick, Fredricton, N.B. Unpubl. Rep.

Riley, C.M. 1992 Continuation of studies to examine the effects of aircraft application parameters on deposit and drift of forestry herbicides. Chemical and biotechnical Services, Research and Productivity Council of New Brunswick, Fredricton, N.B. Rep. No. C/92/443.

McLaughlan, M. 1992. Hexazinone and granular herbicide applicators: A review of the herbicide and available application equipment. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. Tech. Rep. (in progress).

Robinson, C. 1992. A review of alternate vegetation management technologies. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Tech. Rep.

Robinson, C. 1992. A literature review of interspecific competition and competition indices for forest plantations and methods of vegetation sampling. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Tech. Rep.

Wagner, R.G. 1992. VMAP program prospectus. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, Ont.

Whaley, R.E. and F.J. Johnson. 1992. Esnagami brushsaw study: Effects of various concentrations of 2,4-D and glyphosate on trembling aspen (Populus tremuloides Michx.). Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. TN-18. 12 pp.

Newsletter Articles and Other Publications

Hollstedt, C. 1992. Seasonal susceptibility of black spruce, blue-joint grass, jack pine, and red raspberry to Vision®. Ont. Min. Nat. Resour., Online to Northwestern Forestry Developments (in press).

Knaapen, F. 1991. VMAP Program. Ont. Min. Nat. Resour., Online to Central Ontario Forest Technology Developments. Fall 1991. Pp. 5.

Mutchmor, A. 1991. Manual versus chemical tending: effects on vegetation. Ont. Min. Nat. Resour., Online to Central Forestry Developments. Fall 1991. Pp. 2-3.

Robinson, C. 1991. VMAP Update. Ont. Min. Nat. Resour., FGF Online. Winter 1991. Pp. 3.

Strobl, S. 1991. Living a sheltered life continued. Ont. Min. Nat. Resour., F.G.F. Online. Summer 1991. Pp. 1-3.

Wagner, R.G. 1991. Ontario's approach to improving the management of forest vegetation. Forestry on the Hill, Special issue: Herbicide., Canadian Forestry Association, Ottawa, Canada. 1991(5):1-6.

Wagner, R.G. 1991. VMAP: Towards improving forest vegetation management in Ontario. Ont. Min. Nat. Resour., Online to Northwestern Forestry Developments 4(3):1-4.

Wagner, R.G. 1991. Documenting the benefits of herbicides and alternative treatments. Ont. Min. Nat. Resour., Online to Northwestern Forestry Developments 4(3):5.

Wagner, R.G. 1991. Directions and research needs for forest vegetation management in Canada. The Northern Forest Vegetation Manager, May 1991 Newsletter of the Northern Interior Vegetation Management Association, Prince George, B.C. Pp. 4-6.

Whaley, R.E. 1992. Nipigon District ground release: treatment, study and demonstration site. Ont. Min. Nat. Resour., Online to Northwestern Forestry Developments (in press).

Whaley, R.E. and F.J. Johnson. 1992. Esnagami brushsaw study: effects of various concentrations of 2,4-D and glyphosate on trembling aspen (Populus tremuloides michx.). Ont. Min. Nat. Resour., Online to Northwestern Forestry Developments (in press).

Progress Reports

Bell, F.W., C. Hollstedt, J. Simpson, and C. Chourmouzis. 1992. Seasonal susceptibility of jack pine and red raspberry to Vision®. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit., Interim Rep.

Bell, F.W., C. Hollstedt, A. Mallik, and D. Collver. 1992. Seasonal susceptibility of black spruce and blue-joint grass to Vision®. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit., Interim Rep.

Boysen, B. 1992. Gromax®- white pine container outplanting trial, 2nd year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Boysen, B. 1992. Tubex®trial with black walnut, 2nd year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Boysen, B. 1992. Tubex®trial with red oak, 2nd year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Boysen, B. 1992. Tubex®trial with silver maple, 2nd year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Chourmouzis, C. and A.M. Gordon. 1992. Effect of glyphosate on raspberry seed viability. Department of Environmental Biology, University of Guelph, Guelph, Ontario. Interim Rep.

Crabbe, R.S., M. McCooeye, and E.B. Stimson. 1992. Measurement of drift in the 1992 Sevogle field study: a preliminary report. National Research Council, Atmospheric Dispersion Group, Ottawa, Ontario.

Harris, D. 1992. Tubex® - underplant trial with white ash, 1st year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Harris, D. 1992. Tubex®/mulch trial with white ash, 1st year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Sampson, M.G. and P.H. White. 1992. Phytotoxins produced by Bipolaris, for control of Calamagrostis canadensis in forest situations. Project report submitted to the Ont. Min. Nat. Resour.

Strobl, Sylvia. 1992. Tubex®/mulch trial with black walnut, 1st year results. Ont. Min. Nat. Resour., S. Tech. Trans. Unit, Interim Rep.

Weber, M.G. 1992. Plantation performance in relation to varying prescribed fire intensities compared with mechanical site-preparation: progress report. Petawawa National Forestry Institute, Chalk River, Ontario.

Whaley, R. 1992. Nipigon District ground release: treatment, study and demonstration site. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit, Interim Rep.

Conference Proceedings

Thompson, D.G., A.K. Watson, C. Dorworth, M. Dumas, G. Strunz, R. Jobidon, P. Harris, J. Castello, and R.G. Wagner. 1992. Biological weed control research in Canadian forestry. Pp. 522-526 in R.G. Richardson (comp.) Proceedings of the First International Weed Control Congress, Volume II. Monash University, Melbourne, Australia.

Wagner, R.G. 1992. Neighborhood approaches for assessing weed impacts in young forests. Pp. 535-539 in R.G. Richardson (comp.) Proceedings of the First International Weed Control Congress, Volume II. Monash University, Melbourne, Australia.

Workshop Materials

Towill, W.D., F.W. Bell, A.M. Wiensczyk. 1992. Planning a vegetation management strategy. Ont. Min. Nat. Resour., N.W. Ont. For. Tech. Dev. Unit. Binder.

Presentations

Meeting with the Teme-Augama Anishinabai, Temagami, Ontario.

What foresters believe about forest vegetation management. R.G. Wagner.

Undergraduate Silviculture Class. University of Toronto, Ontario.

Forest vegetation management in North America. R.G. Wagner.

Ontario Advanced Forestry Program, Module I. Lakehead University, Thunder Bay, Ontario.

Inter- and intra-specific competition in regulating plant populations. R.G. Wagner.

Planning Vegetation Management Strategies Workshop, NW Ontario Forest Technology Development Unit, Thunder Bay, Ontario.

Autecology of non-crop species. F.W. Bell.

Treatment alternatives. F.W. Bell.

Non-crop response to disturbance. F.W. Bell.

Directions for forest vegetation management in Ontario. R.G. Wagner.

Principles of competition in forest vegetation management. R.G. Wagner.

Planning Vegetation Management Strategies Workshop NW Ontario Forest Technology Development Unit, Dryden, Ontario.

Autecology of non-crop species. F.W. Bell.

Treatment alternatives. F.W. Bell.

Directions for forest vegetation management in Ontario. R.G. Wagner.

Principles of competition in forest vegetation management. R.G. Wagner.

Integrating plant autecology and silvicultural activities to prevent vegetation management problems. R.G. Wagner.

Vegetation Management for the 90s Conference, Northern Forest Development Group and Canadian Institute of Forestry Workshop, Timmins, Ontario.

Directions for forest vegetation management in Ontario. R.G. Wagner.

Principles of competition in vegetation management. R.G. Wagner.

Reducing the need for vegetation management. R.G. Wagner.

Ontario Advanced Forestry Program, Module IV. Lakehead University, Thunder Bay, Ontario.

The direction of forest vegetation management in Ontario in the 1990's. R.G. Wagner.

Operational tending and competition in Ontario. R.G. Wagner.

The toxicity and environmental safety of herbicides. R.G. Wagner.

The combined effects of forest fertilization and weed control on young forest stands. R.G. Wagner.

New Zealand Forest Research Institute, Rotorua, New Zealand.

Research directions for forest vegetation management in North America. R.G. Wagner.